

Planning for a Distributed Disruption: Innovative Practices for Incorporating Distributed Solar into Utility Planning

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Project Overview

Context

- Analysts project that distributed solar photovoltaics (DPV) will continue growing rapidly across the United States.
- Growth in DPV has critical implications for utility planning processes, potentially affecting future infrastructure needs.
- Appropriate techniques to incorporate DPV into utility planning are essential to ensuring reliable operation of the electric system and realizing the full value of DPV.

Approach

- Comparative analysis and evaluation of roughly 30 recent planning studies, identifying innovative practices, lessons learned, and state-of-the-art tools.

Scope

- Electric infrastructure planning (IRPs, transmission, distribution).
- Focus on the treatment of DPV, with emphasis on how DPV growth is accounted for within planning studies.

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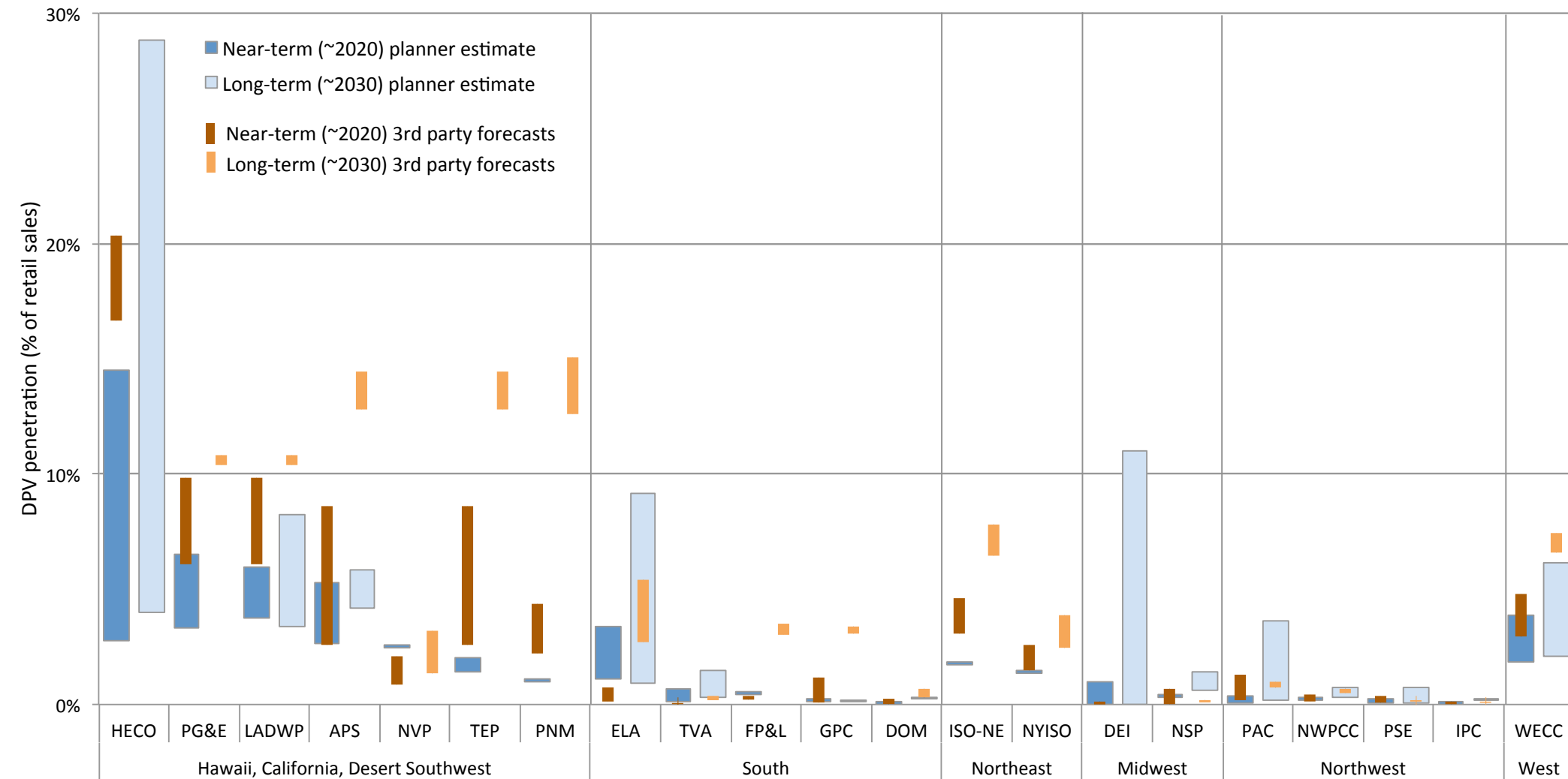
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High End of 3rd Party Forecasts Suggests More DPV Than Is Considered By Utilities



Customer-adoption Modeling Brings Customer Decisions Into DPV Forecasting

Method	Description	Predictive Factors Used				
		Recent installation rates	Incentive program targets	Technical potential	PV economics	End-user behaviors
Stipulated Forecast	Assumes end-point DPV deployment					
Historical Trend	Extrapolates future deployment from historical data	X				
Program-Based Approach	Assumes program deployment targets reached		X			
Customer-Adoption Modeling	Uses adoption models that represent end-user decision making	X		X	X	X

Some Planners Use Customer-adoption Models for DPV Forecasting

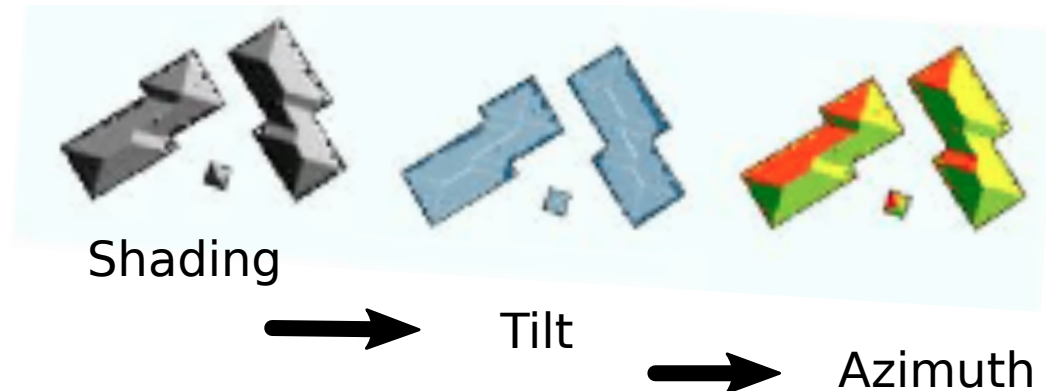
Technical
Potential



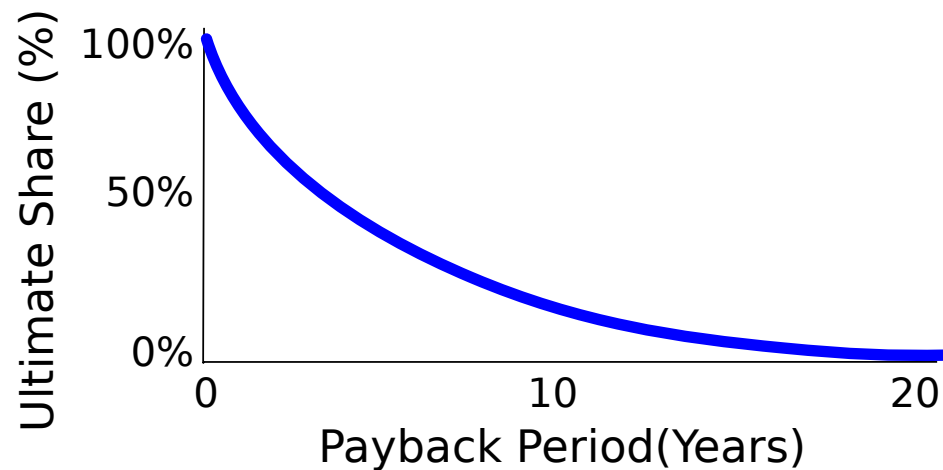
Willingness-
to-adopt



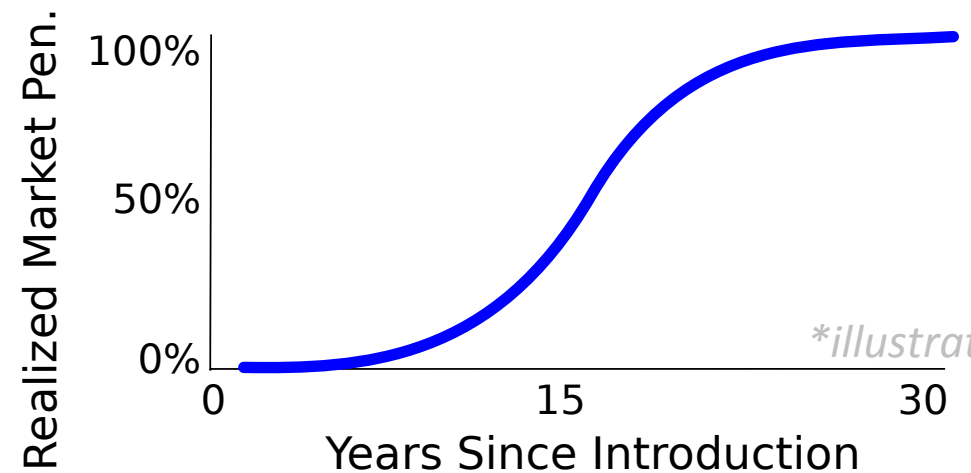
Diffusion



*Adapted from:
Gagnon et al.
2016*



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Multiple Per-scenario Plans Help Identify Resources that Depend on DPV Forecast

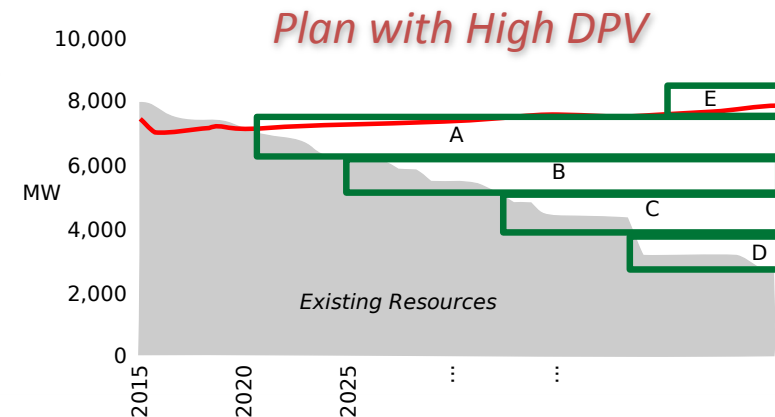
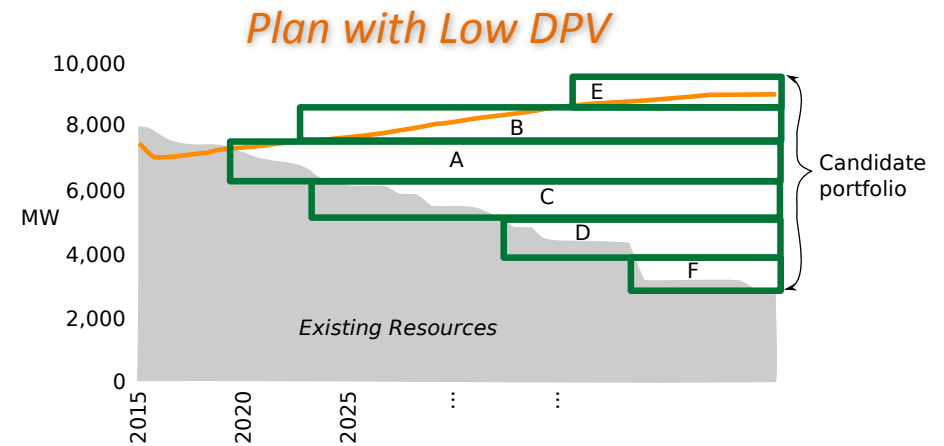
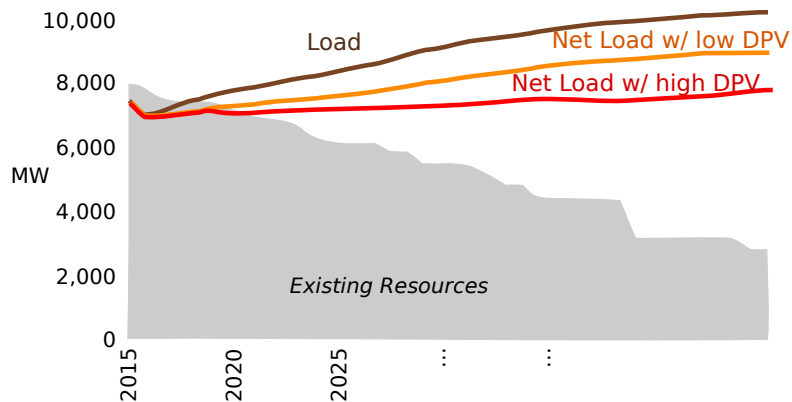
Method	Description	Factors Addressed		
		Net load changes	Generation portfolio changes	Resource-acquisition strategy changes
Single Forecast	One DPV-adoption forecast used			
Subject to Sensitivity	Cost and performance of portfolios evaluated under different sensitivities	X		
Per-Scenario Plan	Capacity expansion models used to develop least-cost plans for various scenarios	X	X	
Acquisition Path Analysis	Multiple per-scenario plans combined with trigger events to shape resource-acquisition strategy	X	X	X

Robustness of Decisions to Uncertainty in DPV Quantity

Forecasts of DPV Adoption are Uncertain



Develop Scenario-Specific Plans



**illustrative*

Use Difference In Plans to Identify Trigger Events and Resulting Changes to Plan

Trigger Event	Planning Scenario	Resource Acquisition Strategy	
		Near Term (2015-24)	Long-Term (2025-34)
Higher sustained DG penetration levels	More aggressive technology cost reductions, improved technology performance, and higher electricity retail rates	<ul style="list-style-type: none"> • Reduce forward contract acquisition • Continue to pursue EE 	<ul style="list-style-type: none"> • <i>Reduce acquisition of gas-fired resources</i> • Balance timing of thermal acquisition with forward contracts and EE
Lower sustained DG penetration levels	Less aggressive technology cost reductions, reduced technology performance, and lower electricity retail rates	<ul style="list-style-type: none"> • Increase forward contract acquisition (primarily beginning 2024) • Continue to pursue EE 	<ul style="list-style-type: none"> • <i>Increase acquisition of gas-fired resources</i> • Balance timing of thermal acquisition with forward contracts and EE

Source: PacifiCorp (2015)

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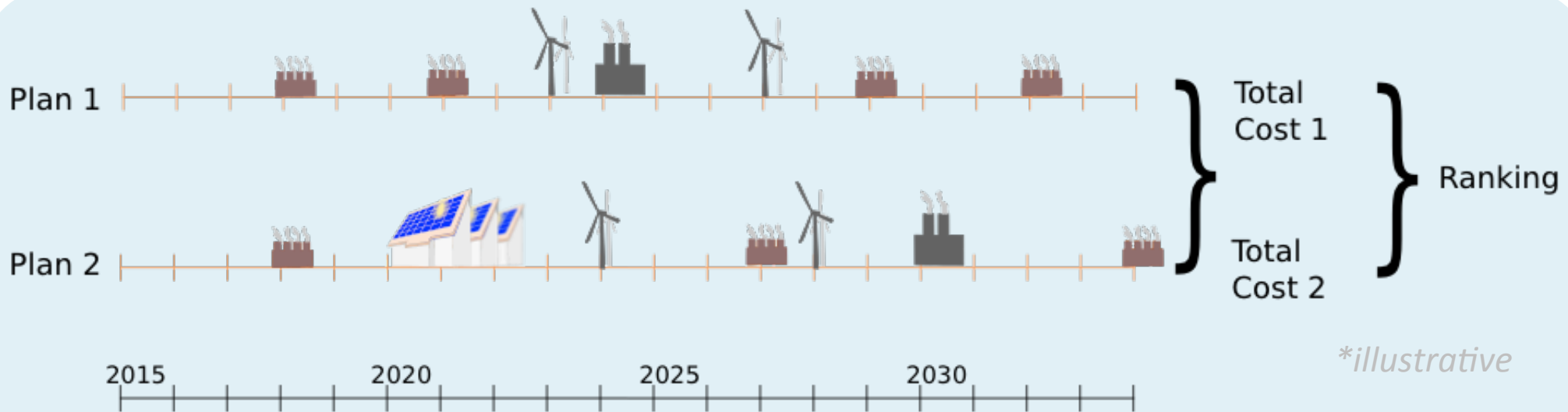
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Characterize DPV as a Resource Option



Only about half of the utility IRPs included DPV as a resource.

The primary challenge is determining how to represent the costs and benefits of DPV and distinguish it from other resources like utility-scale PV (UPV).

Plan	Characteristic					
	Capital Cost Differs from UPV?	Capacity Factor Differs from UPV?	Capacity Credit Differs from UPV?	Avoided Losses	Avoided Transmission	Avoided Distribution
DEI (2015)	X					
GPC (2016)				X	X	
HECO (2013)	X	X				
IPC (2015)			X			
LADWP (2014)	X				X	
NSP (2015)	X	X	X	X		
PG&E (2014)	X	X	X	X	X	X
PSE (2015)	X				X	
TVA (2015)	X					

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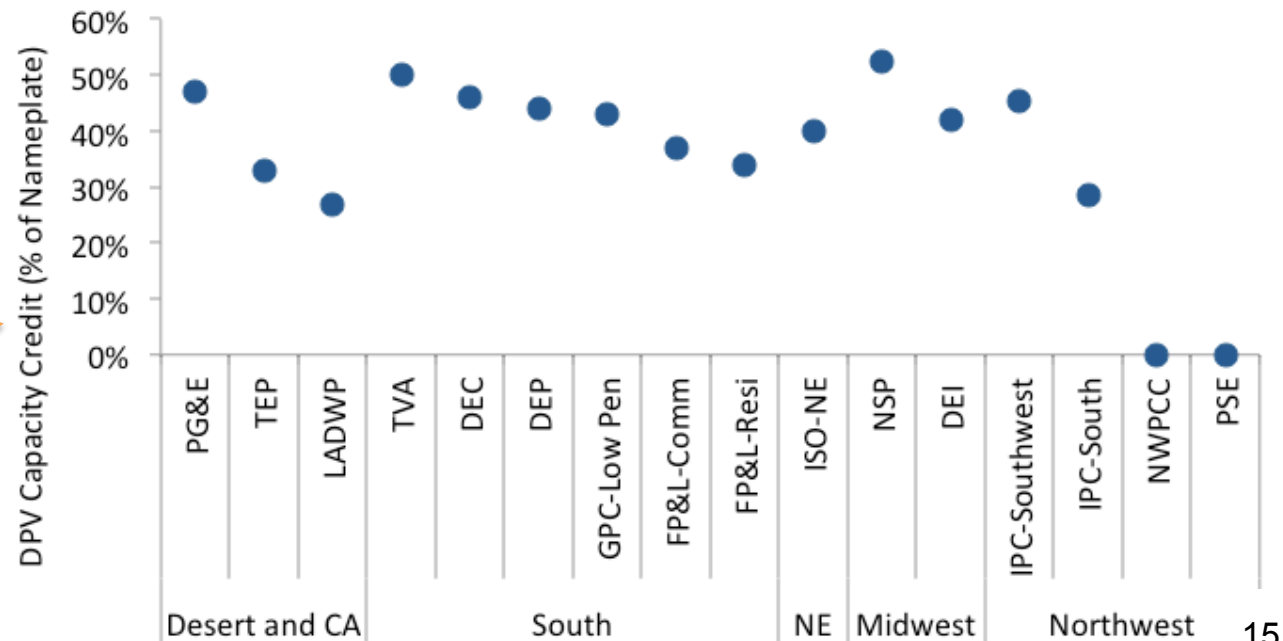
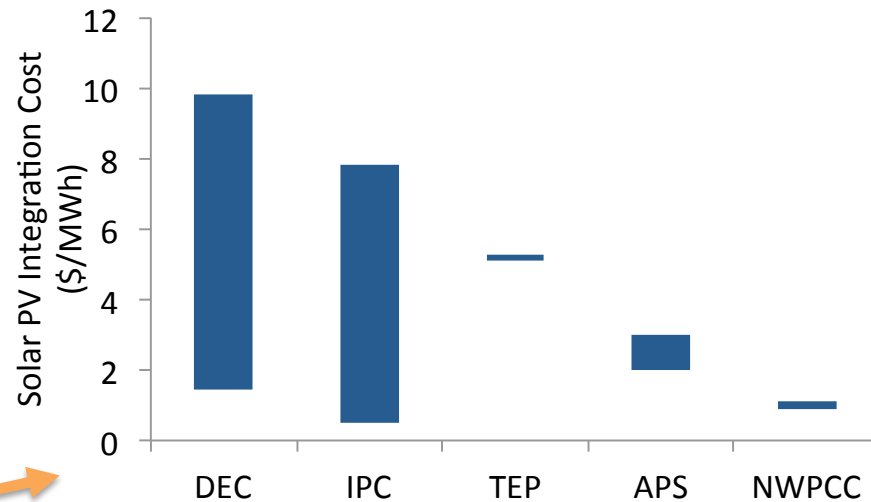
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Evolving Approaches to Capture Non-dispatchability of DPV in Planning

- Hourly DPV generation profiles capture some potential integration issues, including multi-hour ramping impacts and overgeneration.
- Sub-hourly variability and uncertainty can be addressed through detailed integration studies.
- DPV's resource adequacy contribution is estimated by the capacity credit.



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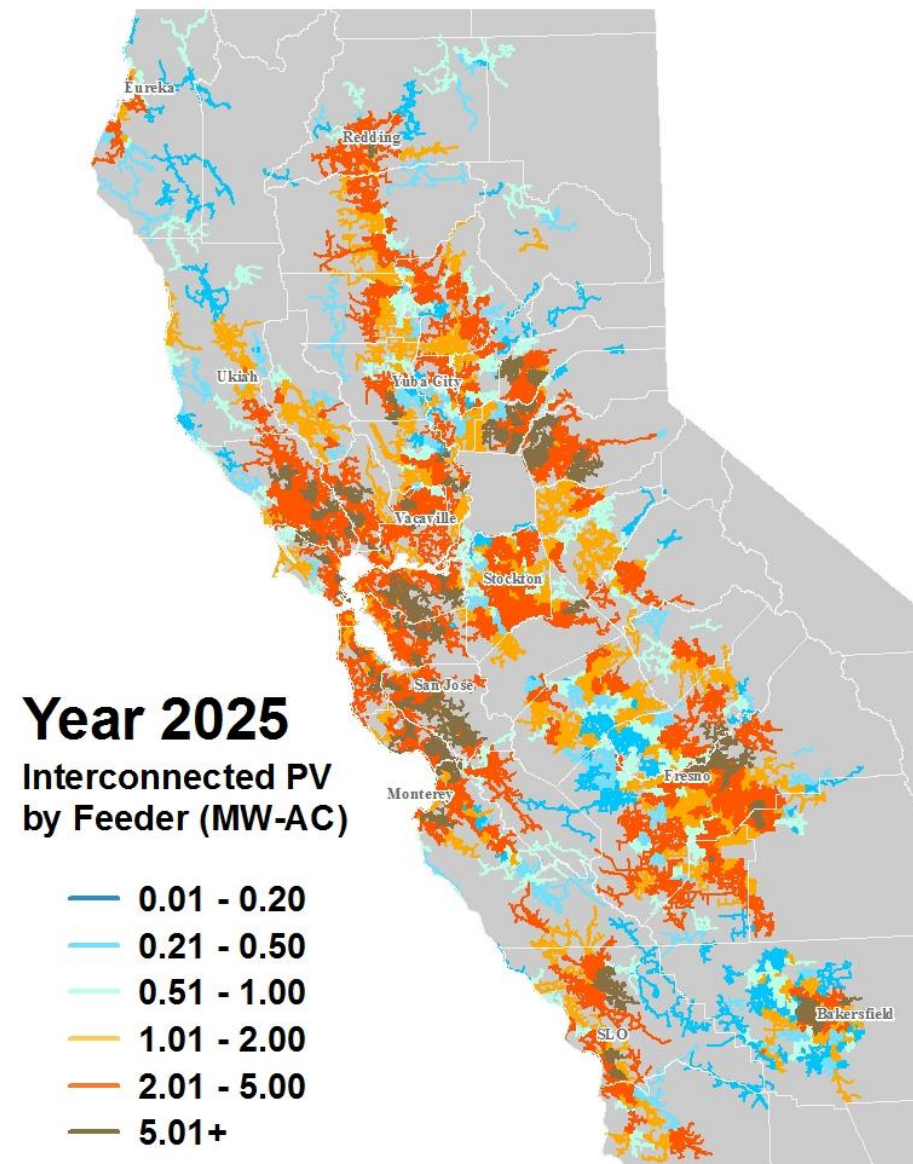
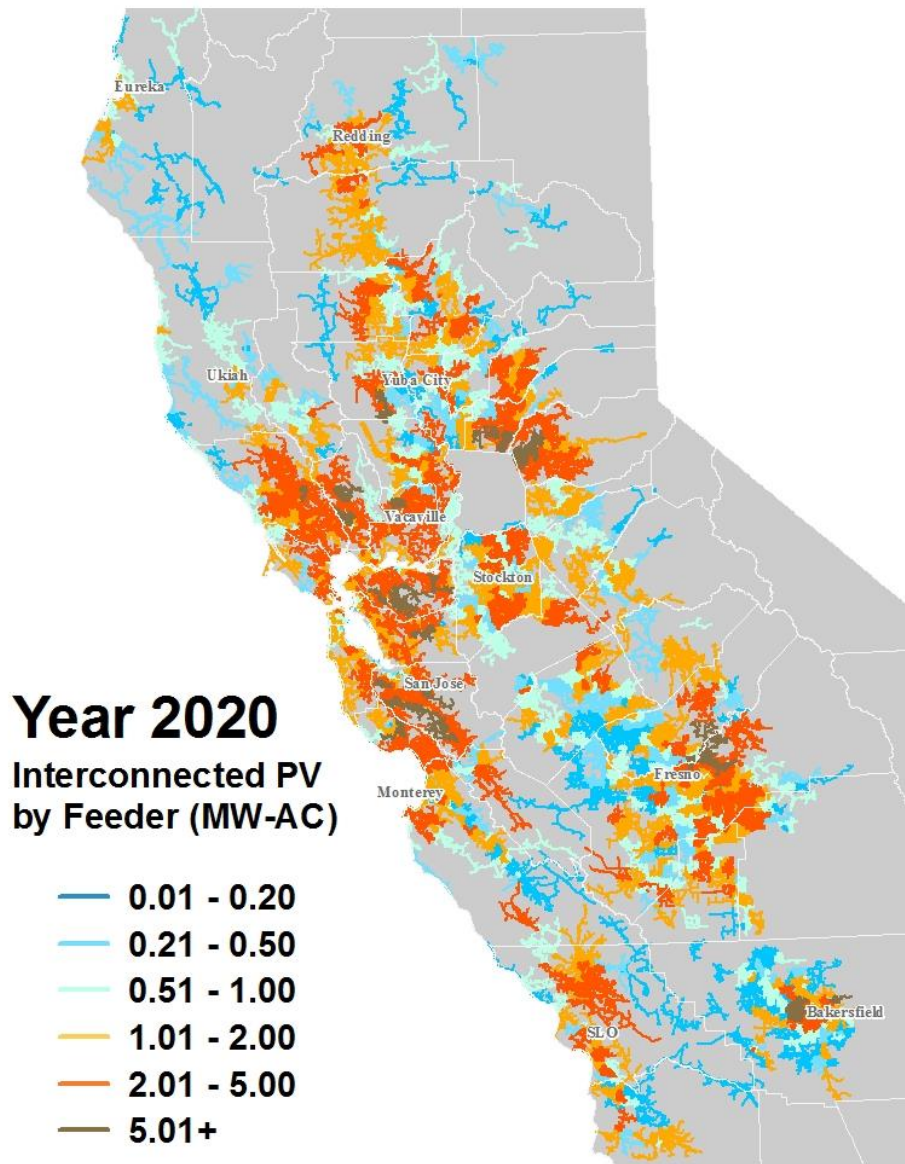
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Propensity to Adopt Accounts for Factors Like Customer Demographics

Method	Description	Predictive Factors Used		
		Location of existing load or population	Location of existing DPV	Detailed customer characteristics
Proportional to Load	Assumes DPV is distributed in proportion to load or population	X		
Proportional to Existing DPV	Assumes DPV grows in proportion to existing DPV		X	
Propensity to Adopt	Predicts customer adoption based on factors like customer demographics or customer load	X	X	X

Predicting the Location of DPV Adoption Using Propensity to Adopt



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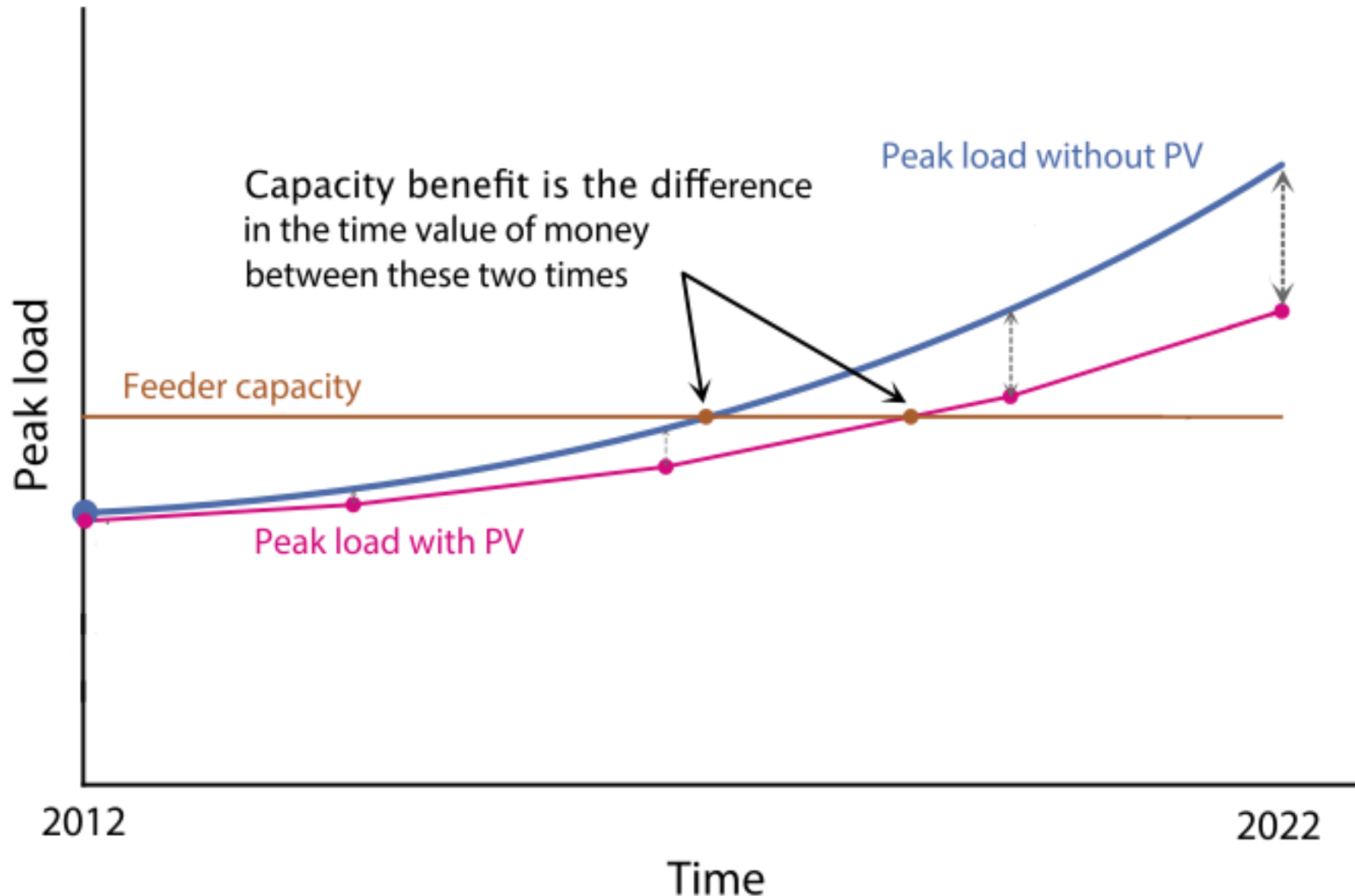
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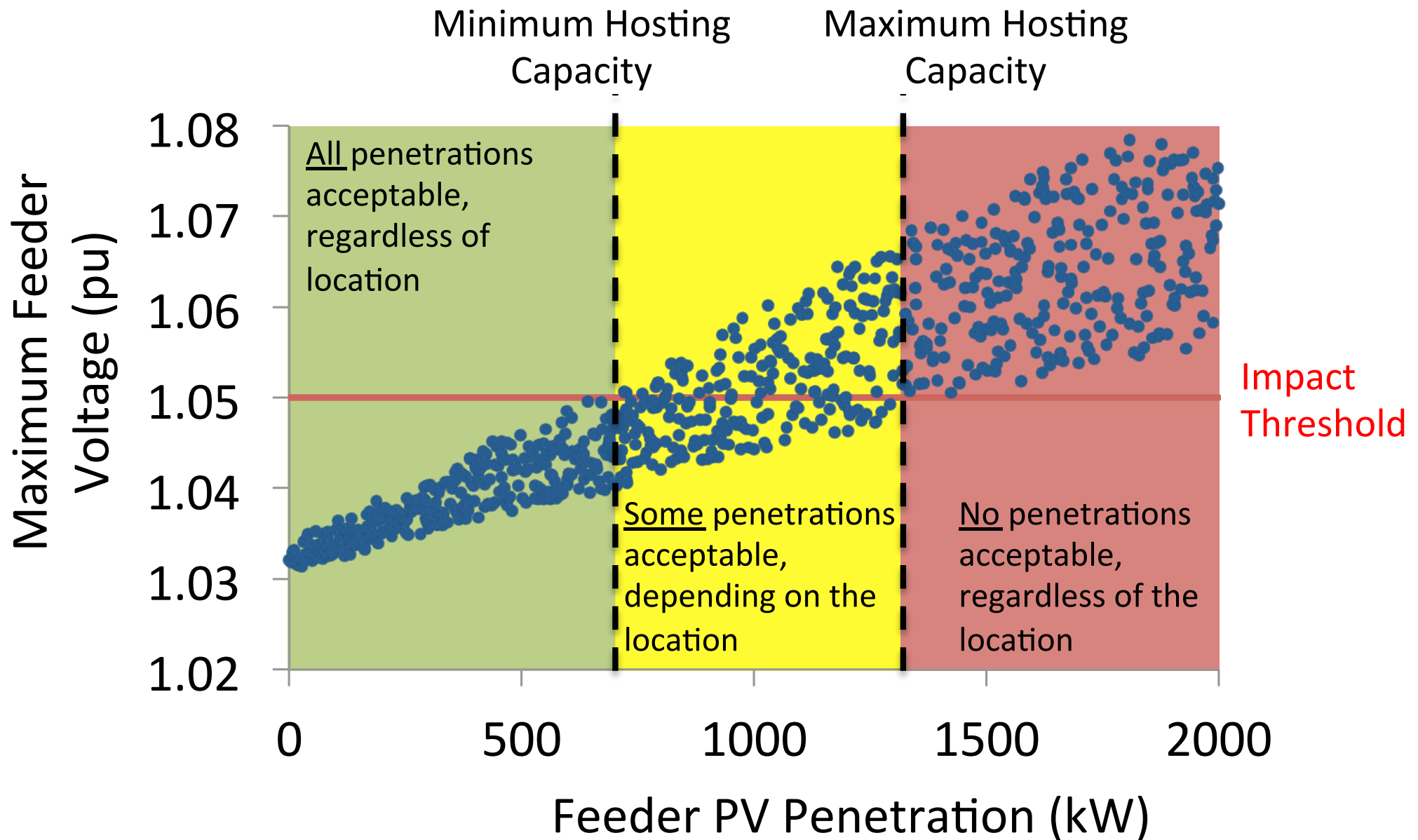
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Impact of DPV on T&D Investments: Potential Deferral Value

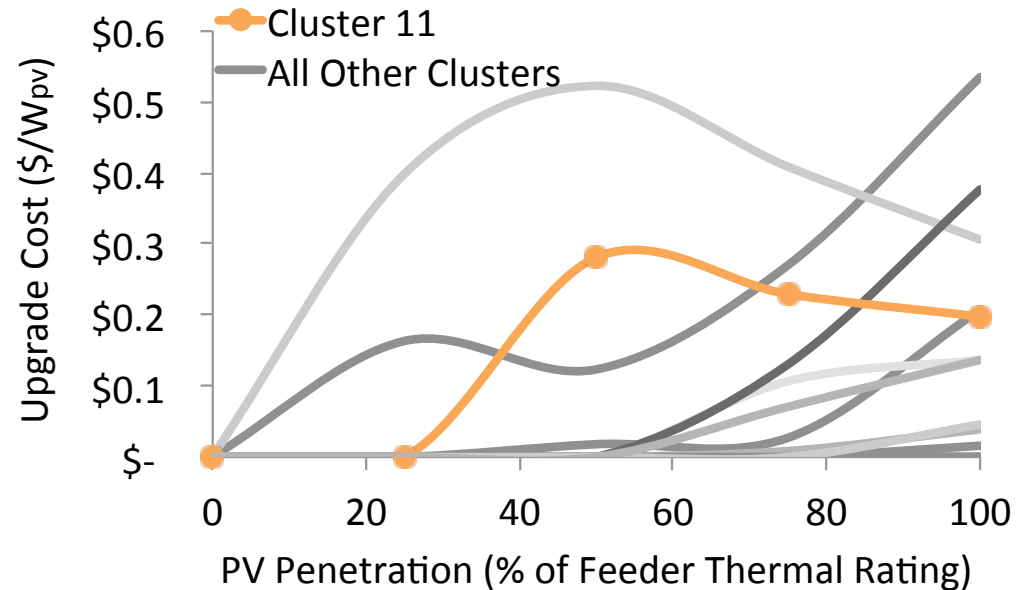


Impact of DPV on T&D Investments: Hosting Capacity Analysis

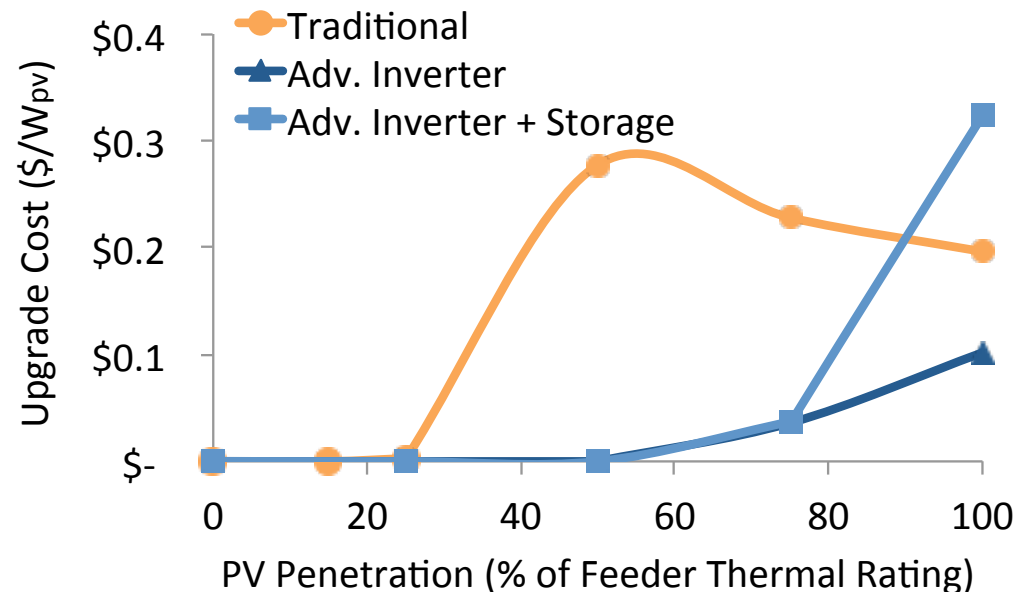


Impact of DPV on T&D Investments: Proactive Planning for DPV

Costs to Increase the
Hosting Capacity of
Fourteen
Representative
Feeders with
Traditional Grid
Upgrades



Costs to Increase the
Hosting Capacity of
Cluster 11 Comparing
Traditional Grid
Upgrades to
Emerging Options



Source: Adapted from Navigant 2016a

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Non-linear Relationship of Losses with Load Is Not Fully Captured in Average Loss Rate

Method	Description	Loss Characteristics Addressed		
		Varied losses over time	Marginal loss rate differs from average	Circuit-level losses
Average Loss Rate	Applies single average loss rate across all hours of the year			
Time-Differentiated Average Loss Rate	Differentiates average loss rate based on timing of avoided losses	X		
Marginal Average Loss Rate	Applies and average marginal loss rate based on line loading		X	
Time-Differentiated Marginal Loss Rate	Differentiates marginal loss rate by hour, month, or “peak” vs. “energy”	X	X	
Detailed Analysis of Losses	Use a circuit-level model to analyze losses	X	X	X

Most utilities appear to use an average loss rate, some use a time-differentiated average loss rate, none appear to use marginal losses.

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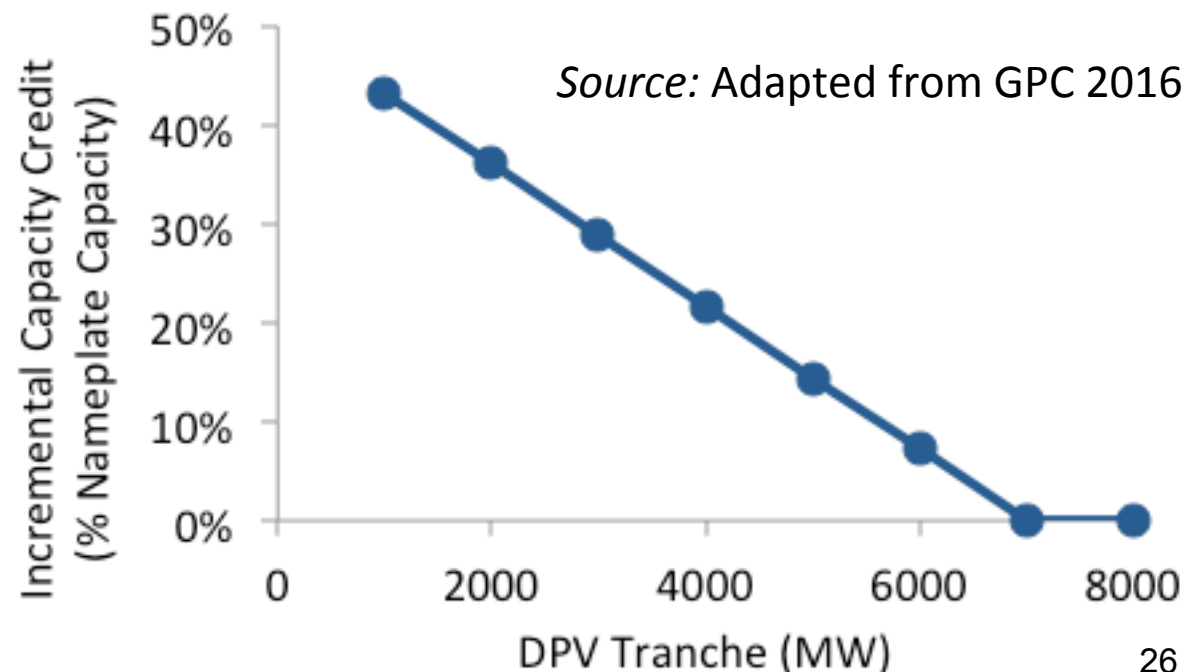
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Studies Contain Few Detailed Discussions of Changes in Value at High Penetration

- Georgia Power estimates value for different tranches of solar penetration, though details are often redacted.
- LADWP identifies challenges with overgeneration on some low-load days with high solar.
- LADWP also notes that electric car charging during the day may mitigate some of the overgeneration challenges.
- Planners may also want to consider bundling DPV with other enabling technologies to prevent changes in value with high penetration.



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Integrating DPV Into Planning Requires Coordination Across Generation, Transmission, and Distribution Planning

- One approach is to ensure that consistent scenarios, assumptions, and data are passed between different planning entities.
- Some utilities are developing iterative planning practices that directly link the different planning forums.
- Emerging tools can help to more fully evaluate the impacts and benefits of DPV and other DER from the distribution system up.

Highlights for Innovative Practices

- **Forecasting:** Customer-adoption modeling for DPV forecasts.
- **Robustness:** Develop scenario-specific plans. Use differences in plans to identify “trigger events” that will result in changes to plan.
- **DPV as a Resource:** Fully characterize DPV as a resource option. Consider in resource, transmission, and distribution planning.
- **Location of DPV:** Forecast location of DPV to improve estimates of the T&D impact and location-specific value of DPV. Use propensity to adopt based on household/customer characteristics.
- **Impacts to T&D:** Include DPV in forecast of peak load for transmission and distribution planning. Use hosting capacity analysis to identify needs for proactive distribution investments.
- **Non-dispatchability:** Use hourly DPV profiles from SAM, CPR, or PVSyst. Calculate contribution to adequacy with ELCC. Use detailed integration studies to investigate sub-hourly challenges and costs.
- **Avoided Losses:** Account for time-varying loss rates.
- **Changes with penetration:** Identify costs and benefits for different tranches of DPV. Consider charging EVs when solar output is high.

Contact Information

For more information:

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<http://emp.lbl.gov/reports/re>

Sample of Integrated Resource Plans

Entity	Title and Year
Arizona Public Service (APS)	2014 Integrated Resource Plan
Dominion (DOM)	2015 Integrated Resource Plan
Duke Energy Carolinas/Progress (DEC/DEP)	2014 Integrated Resource Plan
Duke Energy Indiana (DEI)	2015 Integrated Resource Plan
Entergy Louisiana (ELA)	2015 Integrated Resource Plan
Florida Power & Light (FPL)	Ten Year Power Plant Site Plan: 2015-2024
Georgia Power (GPC)	2016 Integrated Resource Plan
Hawaiian Electric Companies (HECO)	2013 Integrated Resource Planning Report
Idaho Power (IPC)	2015 Integrated Resource Plan
Los Angeles Department of Water and Power (LADWP)	2014 Integrated Resource Plan
Nevada Power (NVP)	2015 Integrated Resource Plan
Northern States Power (NSP)	2015 Resource Plan
Northwest Power and Conservation Council (NWPCC)	Seventh Conservation and Electric Power Plan (2016)
Pacific Gas & Electric (PG&E)	2014 Bundled Procurement Plan
PacifiCorp (PAC)	2015 Integrated Resource Plan
Public Service New Mexico (PNM)	2014 Integrated Resource Plan
Puget Sound Energy (PSE)	2015 Integrated Resource Plan
Tennessee Valley Authority (TVA)	Integrated Resource Plan - 2015 Final Report
Tri-State G&T	2015 Integrated Resource Plan/ Electric Resource Plan
Tucson Electric Power (TEP)	2014 Integrated Resource Plan

Sample of Transmission Planning Studies

Entity	Title and Year
California ISO (CAISO)	2015-2016 Transmission Planning Process Unified Plan. Assumptions and Study Plan
ISO New England (ISO-NE)	2015 Regional System Plan
New York ISO (NYISO)	2015 Load and Capacity Data Report: “Gold Book”
PJM	2015 Regional Transmission Expansion Plan
Western Electricity Coordinating Council (WECC)	Integrated Transmission and Resource Assessment: Summary of 2015 Planning Analyses

Sample of Distribution Planning Studies

Entity	Title and Year
California: PG&E	2015 Distribution Resources Plan
CA: Southern California Edison (SCE)	2015 Distribution Resources Plan
CA: San Diego Gas and Electric (SDG&E)	2015 Distribution Resources Plan
Hawaii: HECO	2014 Distributed Generation Interconnection Plan
HI: HECO	2015 Circuit-Level Hosting Capacity Analysis
Massachusetts: National Grid	2015 Grid Modernization Plan
New York: NY Department of Public Service	2015 Distributed System Implementation Plan Guidance